Name: _____ Class: _____ Date: _____

Forces and the Laws of Motion

# Problem A

## DRAWING FREE-BODY DIAGRAMS

### PROBLEM

A person is pulling a sled. Draw a free-body diagram for this sled. The magnitudes of the forces acting on the sled are 60 N by the string, 130 N by Earth (gravitational force), and 90 N upward by the ground.

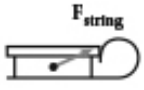
### SOLUTION

1. **Identify the forces acting on the object and the directions of the forces.**
   - The string exerts 60 N on the sled in the direction that the string pulls.
   - Earth exerts a downward force of 130 N on the sled.
   - The ground exerts an upward force of 90 N on the sled.
2. **Draw a diagram to represent the isolated object.**
   It is often helpful to draw a very simple shape with some distinguishing characteristics that will help you visualize the object, as shown in **(a)**. Free-body diagrams are often drawn using simple squares, circles, or even points to represent the object.
3. **Draw and label vector arrows for all external forces acting on the object.**
   A free-body diagram of the sled will show all the forces acting on the sled as if the forces are acting on the center of the sled. First, draw and label an arrow that represents the force exerted by the string attached to the sled. The arrow should point in the same direction as the force that the string exerts on the sled, as in **(b)**.

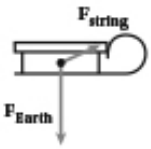
   Next, draw and label the gravitational force, which is directed toward the center of Earth, as shown in **(c)**. Finally, draw and label the upward force exerted by the ground, as shown in **(d)**. Diagram **(d)** is the completed free-body diagram of the sled being pulled.

**(a)**

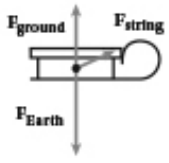
**(b)**




**(c)**




**(d)**



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## ADDITIONAL PRACTICE

1. A truck pulls a trailer on a flat stretch of road. The forces acting on the trailer are the force due to gravity (250 000 N downward), the force exerted by the road (250 000 N upward), and the force exerted by the cable connecting the trailer to the truck (20 000 N to the right). The forces acting on the truck are the force due to gravity (80 000 N downward), the force exerted by the road (80 000 N upward), the force exerted by the cable (20 000 N to the left), and the force causing the truck to move forward (26 400 N to the right).
   a. Draw and label a free-body diagram of the trailer.
   b. Draw and label a free-body diagram of the truck.
2. A chef places an open sack of flour on a kitchen scale. The scale reading of 40 N indicates that the scale is exerting an upward force of 40 N on the sack. The magnitude of this force equals the magnitude of the force of Earth's gravitational attraction on the sack. The chef then exerts an upward force of 10 N on the bag and the scale reading falls to 30 N. Draw a free-body diagram of the latter situation.
3. A music box within the toy shown below plays tunes when the toy is pushed along the floor. As a child pushes along the handlebars with a force of 5 N, the floor exerts a force of 13 N directly upward on the toy. The Earth's gravitational force on the toy is 10 N downward while interactions between the wheels and the floor produce a backward force of 2 N on the toy as it moves. Draw a free-body diagram of the toy as it is being pushed.